Analytic Hierarchy Process for Evaluation of Public Transport Policy Design in Phnom Penh City

Virakvichetra LON [a], Osamu HIGASHI[b], Pharinet PHENG[c]

[a] *Road Infrastructure Department, Ministry of Public Works and Transport, The building of General Directorate of Transport, Phnom Penh, Cambodia*
[a] *E-mail: lon_chetra@yahoo.com*
[b] *Assoc. Prof., Graduate School for International Development and Cooperation, Hiroshima University, Hiroshima, Japan*
[b] *E-mail: hi036@hiroshima-u.ac.jp*
[c] *Project for Comprehensive urban Transport Plan in Phnom Penh, Department of Public Works and Transport, Phnom Penh, Cambodia*
[c] *E-mail: ppharinet@yahoo.com*

Abstract: Vehicle traffic in Phnom Penh City, Cambodia, has worsened recently because of more cars, especially motorbikes, owing to the rapidly increasing population and economic growth within Cambodia. This raises concerns involving future CO_2 emissions. One means of improving the city's traffic problems and reducing CO_2 emissions is to reduce the number of private vehicles on road by developing a public transit system. This study evaluates public transportation choices on the basis of an analytic hierarchy process (AHP) survey conducted to investigate the feasibility, assign priority criteria, and evaluate alternatives on the basis of potential demand in different areas and for various demographics of the city population. AHP is a multicriteria decision-making method applied to solving social, governmental, and corporate decision problems. We aim to use a new method by simplifying the AHP structure on the demand side when applied to residential transportation preferences.

Keywords: AHP, MCDM, Phnom Penh, public transit, demand side, demography

1. INTRODUCTION

Generally, economic growth, education, health, and environment are categories that receive the most attention in developing countries. Urban transport, particularly public transport, remains largely unaddressed (UITP, 2003).

Phnom Penh City is the capital of Cambodia, and attracts a large number of people from surrounding areas who come seeking employment to improve their standard of living. The capital also attracts several investors with its improving infrastructure. Constant increase in population has led to increased numbers of private vehicles every year. As a result, traffic congestion, accidents, and air pollution have significantly increased (JICA, 2001). Predominant transportation modes include private cars, motorbikes, motor taxis, Tuk Tuk (a public transport vehicle with three wheels), Cyclos (scooters), and minibuses for some schools. A 2008 population census indicated that households average five members and most of them have their own vehicles (NIS, 2010). Additionally, the used cars are not export to any country, they were purchased by medium-income people who can effort to buy and pay tax (General Department of Taxation, 2010).

JICA's (2001) Urban Master Plan of Phnom Penh City for 2020 mentioned that land use, narrow roads, and parking areas are the main contributors to traffic congestion. There are

many road sections that are only 5–7 m wide, and impatient drivers will not yield right of way to drivers approaching from the other side, causing gridlocks. Moreover, around 805 parking areas are in need for operation because of the number of vehicles running in popular areas such as the Main Street (Embassy of France in Cambodia, 2002–2005).

Traffic problems are further exacerbated by people selling items or running their business on the pavement or sidewalk, forcing pedestrians to detour onto the street.

JICA (2001) attempted to implement public transit through the Bus Rapid Transit system inside the city, but the service failed. In terms of bus service attributes, high bus fare and lack of comfort were found to be the most important considerations for passengers in Phnom Penh (Kasem CHOOCHARUKUL and Meng Hong UNG, 2011). [Remark 1] Because the city budget allotment for developing public transit is low, ranking and understanding the priority of travel criteria for potential passengers are important. We employ the analytic hierarchy process (AHP) to give a clear recommendation to decision makers and to indicate the priorities to attract passengers for public transport.

Guiver (2007) found that many models have been introduced for measuring the increase in transportation and the influence of different factors on travel choices; moreover, these models are usually mathematical. He reiterated that "influences which are amenable to measurement tend to be privileged over factors which are less measurable, such as levels of service, reliability, status and comfort -because they rely on quantitative measurements." To assist his analysis, he conducted detailed interviews with various households to determine their opinions regarding the use of cars and public transportation. Data were collected using the transcripts collected from 10 focus groups in different locations. Each group consisted of 9–10 respondents including car users, car and bus users, men, women, teenagers, and their parents.

After collecting data, he used Atlas Ti, a software package for analyzing text. The results of the data analysis revealed that the detractors to using buses in a worst-case scenario included the issues of safety, schedule, comfort, and freedom of movement. The analysis pointed out the scenarios that would allow planners or investors to improve any existing negative conditions in their operations.

"Travel behavior is a complex. Deep understanding of people's perception, attitudes and behavior is needed," said Beirao and Cabral (2007) in Porto. These researchers chose qualitative methods to solve a public transportation problem as this method was considered a useful instrument for determining public transport complexities (Clifton and Handy, 2001). In the travel decision-making process, emotions played a vital role. Hence, qualitative research allows exploration of respondents' emotions without the constraints of quantitative methods (Grosvenor, 2000) conducted detailed interviews with 24 participants of the general public, including regular and occasional users of cars and other public transportation.

Newbold et al. (2005) studied the travel behavior of Canadians aged 65 years or more to determine if their travel patterns were different from those of younger Canadians. Their study used data from the General Social Survey of Canada. The data from approximately 19,000 participants provided a partial confirmation of the research question, but recognized that 12 factors other than age can influence travel behavior. Older Canadians do make fewer daily trips than younger Canadians, but this could be because the participants in the study were no longer employed and hence were no longer making travel-to-work journeys. Thus, daily trip numbers and duration decreased significantly because of changes in employment and health status. In addition, there was a greater reliance on cars and a significant reduction in the use of public transportation as the principal travel mode compared with younger Canadians. In addition, Guiliano (2003), Guiliano & Narayan (2003), and Guiliano & Dargay (2006) found that participants aged 65 years or older in the United Kingdom traveled half the distance, and on any given day, were less likely to travel than participants aged 18–64 years. In a US study,

participants aged 65 years or more traveled 60% of the distance traveled by younger participants.

Rosenbloom and Fielding (1998) identified 11 groups as being more likely than average to use public transit as their principal mode for commuting to work, independent of their income or the size or density of the metropolitan areas in which they lived. These included workers with low income, workers with no household cars, workers with a college education, blacks, Hispanics, workers with graduate school education, workers aged 17–29, women, Asians, immigrants who had been in the United States for less than 10 years, and workers with mobility or work limitations. Thus, female workers require transit services that not only reduce travel time, but more importantly, provide personal security. In addition, Rosenbloom and Fielding found that many low-income workers live in city outskirts and commute regularly to suburban areas. Transportation schemes for these workers were normally direct reverse-commute services, feeder services, or from suburban transit stops and stations to their actual employment sites and vice-. These workers also required additional or targeted service information. In addition, people aged 17–29 years were slightly more responsive to cost attributes and very responsive to fare incentives, relaxed transfer policies, and subsidized carpools. Although people aged 65 and older were more likely to use public transit for work and non-work trips, the market share among them was falling in most service environments. Transportation services that provide the convenience and safety of cars, such as taxis and demand-responsive services, attracted elderly users. However, these travelers were also drawn to customized but regular transit concepts such as service routes, community buses, and derivatives of these services.

Differences in travel behavior because of gender has been a significant factor in many previous studies, with women recognized as being more likely to adopt sustainable travel behaviors compared to men. Best & Lanzendorf (2005) attempted to determine if there were gender differences in car use and travel patterns in daily errand trips. They found that, generally, there were no significant differences in the total number of trips or distances traveled between men and women. However, the type or destination of trips did provide some gender differences. They revealed that women made fewer journeys to work by car, but used cars more frequently for daily errand activities such as shopping and childcare. This was also confirmed by Boarnet & Sarmiento (1998) in their study of travel behavior in southern California. Moriarty & Honnery (2005) studied urban travel in all Australian State capital cities. Although the major emphasis was on the relationship between the distance from the place of residence to the Central Business District (CBD) of each city and the impact on travel behavior, their study found that women on average travel less often and for shorter distances than men. Moreover, Olaru et al. (2005) studied the travel behavior in the Sydney metropolitan area and found several socio-demographic variables influencing travel behavior. Women were more likely to travel closer to home than men. Perhaps the strongest link between travel behavior and gender was found by Polk (2003, 2004) in studies of travel behavior in Sweden in 1996. Polk found a significant relationship between sustainable travel patterns and gender. According to the study results, women were more willing to reduce car use than men, which is a positive step toward reducing the environmental impact of travel modes. Polk concluded that researchers must consider gender as a factor in attitudinal research on car use.

Handy et al. (2005) found similar outcomes despite a very different mix of participants and methodologies. Their study used focus groups and face-to-face interviews with students and staff at the University of Austin, Texas, to determine if Americans drive by choice or necessity. The study revealed that Americans drive because of the price of a trip and lack of suitable modal alternatives. Therefore, the authors suggested a stronger policy agenda on reducing the need for driving through the provision of a public transport infrastructure at a

suitable cost to passengers.

Cantwell, Caulfield, & O'Mahony (2007) conducted a linear regression analysis to ascertain the relationship between travel time and commuter satisfaction. The result showed this relationship to be positive. This implies that the longer a respondent spends traveling to work, the lower the satisfaction level in commuting. Moreover, respondents averaged 10 min waiting time for transportation to and from work.

The majority of previous studies have focused on existing bus services, while few studies have been conducted on bus service planning particularly on a city without any existing proper public transportation, like Phnom Penh. In order to introduce an efficient bus service, an understanding of passengers' attitudes and requirements toward bus service attributes is necessary. According to the studies discussed above, the authors chose AHP as a tool to analys the factors priority. AHP was used as an evaluation tool by breaking down the problem of the criteria and alternatives to prioritize their significance with respect to the goal of developing and implementing a public transportation system. On the basis of previous research, different factors were found pertinent when considering a public transportation system or alternative transportation choices. These factors can be categorized and summarized in the table below.

Categories	Factors
1. External Factor/ Demography	Age
	Gender
	Job
	Location
	Vehicle Ownership
2. Internal Factor	Travel Cost
	Waiting Time
	Travel Time
	Comfort
	Safety

Source: Arranged by the author

2. METHODOLOGY

2.1 Data collection

Phnom Penh occupies 678.46 km^2 (0.37% of Cambodia), with a current population of 1,327,615 residents and a population density of 4,571.1 persons/km^2 (NIS, July 2010). There are eight districts (Khans) in the city, with four being in the central part of the city. Fig. 1 shows a map of all districts in Phnom Penh City, and the red circles indicate the survey areas selected for this study.

Each community in the four outer districts was selected randomly. As the four central districts compose the CBD, the authors chose five locations at a distance of 12 km from the CBD and four locations at a distance of 6 km from the CBD.

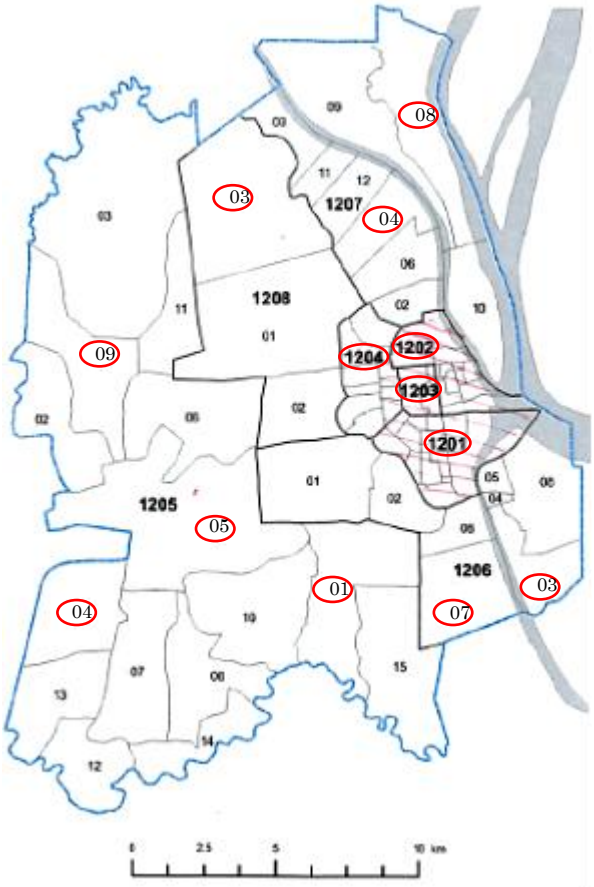

Figure 1. Survey areas selected in Phnom Penh City

2.2 Sampling

The authors randomly selected participants in each suburb location along a highway and approximately 300 m from an access road. On the other hand, all participants in the four central districts were selected along the Main Street. The authors purposely selected only public workers and students from the Build Bright University in the central district. Many students use their cars to drive to and from the university, so they were considered an interesting survey group.

The authors used a total sampling of 500 participants, 40 participants in each of the 13 locations, nine locations from suburban areas and four from the central district. One location used only 20 respondents because the area is scarcely populated, and other 20 survey samples were used as the Pilot survey. Table 1 gives the particulars on the participants selected and the district details.

Table 1. Survey of administration details

Zone Number	District Name	Location Name	Type	No. of Question naire	18–29	30–63	64–74	Male	Female	Workers	Students	Other	Car	Motor bike
1203	7 Makhara		CBD	40	9	29	2	29	11	20	20	0	8	22
1201	Chamkar Morn		CBD	40	8	31	1	24	16	27	13	0	12	28
1202	Donpenh		CBD	40	11	29	0	25	15	20	20	0	6	31
1204	Toul Kork		CBD	40	9	31	0	23	17	21	19	0	13	26
120509	Dangkor	Samraong Kroam	Suburb	40	0	32	8	20	20	9	0	31	2	7
120505		Chaom Chao	Suburb	40	1	37	2	21	19	28	0	12	5	25
120504		Plerng Chhesroteh	Suburb	20	0	19	1	3	17	2	0	18	0	1
120501		Dangkor	Suburb	40	2	34	4	8	32	12	4	24	0	13
120607	Mean Chey	Chak Angrar Kraom	Suburb	40	0	35	5	23	17	19	0	21	6	14
120608		Nirouth	Suburb	40	0	30	10	25	15	23	0	17	2	18
120803	Sensok	Khmounh	Suburb	40	1	38	1	23	17	17	0	23	2	28
120704	Russei Koe	Kilometre 6	Suburb	40	0	37	3	25	15	16	2	22	2	12
120708		Prek Liep	Suburb	40	1	33	6	28	12	19	0	21	1	23
Total				500	42	415	43	277	223	233	78	189	59	248

2.3 Research instrument

AHP was developed by Saaty in the late 1970s. There were two parts to the survey instrument: one was based on social-economic characteristics related to the respondents' location, age, gender, etc., as shown in Appendix A-1. The other part was the AHP survey questionnaire shown in Appendix A-2.

In order to develop the questionnaire, the AHP structure was produced using step 1 of the four steps described by Johnson (1980). Figure 2 shows how the decision hierarchy is set up by breaking down the dilemmas of the decision into three levels of interrelated decision elements (Saaty 1977a, 1977b, 1977c, 1977d, 1978b, 1980). Finally, the authors develop the structure in 3 different levels; Level 1 is the goal, level 2 is the criteria, and the last level represents the alternatives of transportation choices.

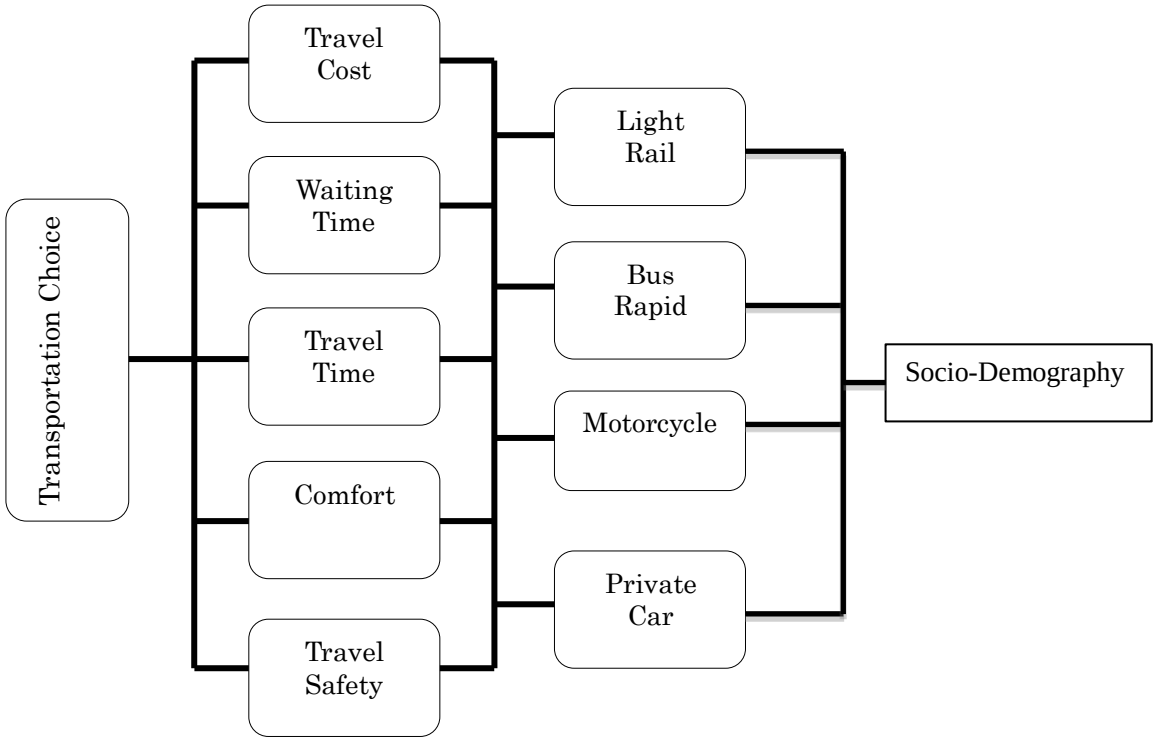

Figure 2. AHP structure decision model for transportation choice.

At level 2, five criteria—Cost, Waiting Time, Travel Time, Comfort, and Safety—were selected. Criteria selection was based on Kasem CHOOCHARUKUL and Meng Hong UNG (2011), who conducted a state preference survey using the following criteria—Fare, Waiting Time, Heading Time, and Bus comfort—in Phnom Penh City. Moreover, Guiver (2007) used Modal talk, a discourse analysis tool, to evaluate how people talk about bus and car travel, and found that most people cared about Cost, Timing (Waiting Time and Travel Time), Comfort, and Route Information. In addition, Hine and Scott (2000) conducted detailed interviews in Scotland regarding public transportation of non-users, car users, and taxi users, and found that public transportation could become more attractive to all users, depending on Accurate Information, Walking Distance, Waiting Time, Cost of Public Transport, and Safety.

There is no intra-city bus in Phnom Penh City; therefore, information criteria were not reliable in this case, as participants had no previous experience with transportation schedules. Thus, the authors selected Cost, Internal Environment (Comfort), Waiting Time, Travel Time, and Safety for level 2 criteria. Car and Motorbike were selected as the two alternative criteria in Level 3 because of their prominent use in Phnom Penh. On the basis of MPWT (2010) data, the number of registered motorbikes increased by 236,614 and that of car registrations increased by 24,355 from the previous year. The authors carefully chose two public transportation possibilities, Bus and Light Rail, which appear to be the best choices for Phnom Penh City on the basis of Travel Distance, Travel Speed, Price, Road Width, and Ease of Implementing Necessary Infrastructure.

The AHP pairwise comparison of each criterion and alternative was complicated and could be easily misunderstood by survey participants, and one day was necessary to complete the pilot survey at one location. In order to avoid further confusion, the authors gathered all assistants to explain them all parts of the survey content until the assistants were thoroughly familiar with the survey questions and their intent. According to Saaty (1995), use of group discussions and/or brainstorming and idea sharing provide better results than reliance on a single decision maker in order to reduce any unintentional bias by a single dominant individual. Group interviews were conducted in suburb areas, but proved difficult to be conducted in urban and CBD areas. Consequently, the authors interviewed the respondents one by one in order to prevent misfiling of questionnaires in the latter case.

In the AHP questionnaire comparisons, the author and assistants asked participants to compare each criterion by assigning a score from 1 to 9 to each alternative (Table 2).

Individual participants' opinions were then synthesized into a single opinion by calculating the geometric mean in order to obtain a single overall result of the priorities for each criterion at each hierarchy level. The geometric mean for synthesizing individual judgments is shown in equations 1 and 2.

$$(a_1, a_2, \ldots, a_n) \equiv \left(\prod_{i=1}^{n} a_i \right)^{1/n} \tag{1}$$

Thus,

$$G(a_1, a_2, \ldots a_n) = (a_1 \times a_2 \ldots \times a_n)^{1/n} \tag{2}$$

where

G : Geometric mean
a : Pairwise comparison scale given by demand side
n : Number of respondents

Table 2. Nine-point scale for pairwise comparisons in AHP

Intensity of	Definition	Explanation
1	Equal importance	Two criteria/sub-criteria contribute equally to the level above
3	Moderate importance	Judgment slightly favors on criterion/sub-criterion over another
5	Essential or strong importance	Judgment strongly favors on criterion/ sub-criterion over another
7	Very strong importance	A factor is strongly favored and its dominance demonstrated in practice
9	Extreme importance	The evidence of favoring one factor over another is of the highest possible order of affirmation
2,5,6,8	Immediate values between above scale values	Absolute judgment cannot be given and a compromise is required

Source: Saaty, 1980

3. RESULT OF PRIORITY WEIGHTS

3.1 Zone scenario of factor prioritization

On the basis of Lon et al. (2012), expert choice was applied to synthesize AHP comparisons of each level in both local and global survey responses. Table 3 identifies each criterion, where the AHP tree factors are shown in rows and the transportation alternatives in columns, under the overall heading of total sampling. In addition, column consistency ratio (CR) shows the value of consistency of pairwise matrix scores, which must be less than 0.10 ($CR < 0.10$). λ_{max} is the maximum Eigen value and is greater than n (where n is the total number of eigenvalues).

In this zone scenario, research focused on three locations: 0 km from the CBD, 6 km from the CBD, and 12 km from the CBD. The intent was to capture different preferences in these locations. In Table 3, distance 0 km from the CBD indicates an area within the CBD. In this category, Travel Cost scores 14.3%, Comfort 13.7%, and Waiting Time 12.4%. Safety and Travel Time were given high priorities by survey participants, with scores of 40.2% and 19.4%, respectively. The major reasons for the emphasis of Travel Time over Waiting Time and Comfort criteria were the preferences of business people within the CBD, who do not like traffic congestion. According to Table 3, Overall EV indicates that persons within the CBD have highest preference for Car Travel (35.1%) and least preference for Motorbike travel (19.1%).

Table 3. Weights of alternative criteria and goals of each zone

Goal: Transportation Choice, Unit % for Distance 0 km from CBD						
		Car	Mot	BRT	LRT	CR
Overall EV		35.1	19.1	24.0	21.0	0.04
TC	14.3	20.7	29.3	2.7	16.8	0.05
WT	12.4	32.0	39.2	14.4	15.2	0.00
Com	13.7	41.7	13.4	25.7	19.5	0.04
TT	19.4	34.7	18.0	23.7	20.8	0.09
Saf	40.2	39.1	13.8	27.6	22.9	0.05
Goal: Transportation Choice, Unit % for Distance 6 km from CBD						
		Car	Mot	BRT	LRT	CR
Overall EV		35.8	17.1	22.7	24.4	0.04
TC	9.1	13.8	36.3	32.0	17.9	0.04
WT	12.7	40.0	20.0	20.0	20.0	0.00
Com	18.1	42.4	12.2	22.7	22.7	0.00
TT	20.5	24.6	20.4	20.4	34.7	0.02
Saf	39.6	42.4	12.2	22.7	22.7	0.09
Goal: Transportation Choice, Unit % for Distance 12 km from CBD						
		Car	Mot	BRT	LRT	CR
Overall EV		28.3	23.8	23.9	24.0	0.03
TC	8.1	11.8	48.7	27.6	11.8	0.06
WT	12.1	33.3	33.3	16.7	16.7	0.00
Com	12.1	28.6	14.3	28.6	28.6	0.00
TT	18.6	16.8	38.6	24.2	20.4	0.07
Saf	49.2	34.0	14.0	23.9	28.1	0.02

Note: TC = Travel Time; WT = Waiting Time; Com = Comfort; TT = Trave Time; Saf = Safety; EV = Eigenvector; Mot = Motorbike; BRT = Bus Rapid Transit; LRT = Light Rail Transit

Source: Arranged by the authors

Survey results revealed that people living within the CBD (0 km) are seven times more likely to commute to work than those living in the other two locations. In all three survey areas, Car is the preferred transportation mode and Motorbike is the least preferred. Surprisingly, in 0 and 6 km, Public Transport (BRT and LRT) were the second and third choices, respectively, where the assumption would have been that Motorbike would receive high scores because of the number of motorbikes in use. In the 12 km distance, there was a small difference between private vehicle and public transport scores. In this zone, people do not travel much to work, as most of them are exporters who work from home or local offices.

3.2 Age scenario, factor prioritization

Age groups were separated into three categories: ages 18–29 were referred to as young passengers, 30–63 were middle-age passengers, and 64–74 were senior citizens or elders. Table 4 shows the scores for Criteria and Alternative choices of each age group. The priority alternatives of the young group are Car (35.4%), Motorbike (27.3%), BRT (20.4%), and LRT

(16.9%). In this age group, the most important criteria are Safety (44.5%) and Travel Time (17.9%). However, in the middle-age group, the two most popular alternatives are Car (41.0%) and LRT (22.2%), followed by BRT (21.1%) and Motorbike (15.6%). The main reason was that the middle-age group consisted of mostly workers, so Safety and Travel Time were important factors considered by this group, with scores of 47.1% and 20.2%, respectively. For this age group, Motorbike received only 8.2% preference.

There were significant differences in the results of the senior citizen group compared to the first two age groups. Senior citizens averaged only two trips per week compared to nearly six trips per week for the young category and five mean trips per week for the middle-age category. In reality, the senior citizens surveyed were people who were no longer employed and hence, were no longer doing travel-to-work journeys, similar to the study conducted by Newbold et al. (2005).

Table 4. Weight of Alternatives with respect to age

Goal: Transportation Choice, Unit % for Age 18–29						
		Car	Mot	BRT	LRT	CR
Overall EV		35.4	27.3	20.4	16.9	0.02
TC	17.9	20	40	20	20	0.003
WT	11	37.5	37.5	12.5	12.5	0.003
Com	11.6	39.5	14	23.2	23.2	0.02
TT	15	36.9	37.4	14	11.7	0.02
Saf	44.5	39.5	19.8	23.9	16.8	0.02
Goal: Transportation Choice, Unit % for Age 30–63						
		Car	Mot	BRT	LRT	CR
Overall EV		41	15.6	21.1	22.2	0.06
TC	8.8	9.4	51.4	19.1	20.1	0.08
WT	10	51.6	15.6	12.4	20.4	0.08
Com	13.8	33.3	17.5	20.7	28.8	0.07
TT	20.2	35.4	16.1	13.1	35.4	0.007
Saf	47.1	49.4	8.2	27	15.4	0.09
Goal: Transportation Choice, Unit % for Age 64–74						
		Car	Mot	BRT	LRT	CR
Overall EV		26.6	21.3	26	26	0.03
TC	10.6	16.3	39.5	27.8	16.3	0.02
WT	13.4	24.6	24.6	21	29.8	0.02
Com	15.8	25	25	25	25	0.004
TT	18.4	25	25	25	25	0.003
Saf	41.9	31.2	12.7	28	28	0.003

Note: TC = Travel Time; WT = Waiting Time; Com = Comfort; TT = Trave Time; Saf = Safety; EV = Eigenvector; Mot = Motor Bike; BRT = Bus Rapid Transit; LRT = Light Rail Transit

3.3 Occupation scenario, factor prioritization

In this scenario, the authors compared the relationship between factors and alternatives with occupation of the survey participants. Table 5 shows the three different types of occupations: Worker (Office staff), Student, and Other (Exploiter). In Table 5, the attribute in the first level showed no significant difference for the ranking because the highest consideration was given to Safety (43.1%–50.7%), followed by Travel Time (16.2%–25.6%). For the Worker's choice, there was a slight difference in three other parameters. Travel Cost and Comfort both had a score of 12.3%, slightly higher than Waiting Time with only 10.2% score.

Table 5. Weight of Alternatives with respect to occupation

Goal: Transportation Choice, Unit % for Worker						
		Car	Mot	BRT	LRT	CR
Overall EV		27.8	22.4	16.1	33.9	0.03
TC	12.3	8.5	50.7	20.4	20.4	0.03
WT	10.2	37.5	37.5	12.5	12.5	0.00
Com	12.3	22.3	12.7	16.2	48.7	0.06
TT	16.2	12.5	37.5	12.5	37.5	0.00
Saf	49.1	36.8	9.6	16.9	36.8	0.06
Goal: Transportation Choice, Unit % for Students						
		Car	Mot	BRT	LRT	CR
Overall EV		42.5	18.1	17.4	22.0	0.06
TC	5.8	12.7	48.7	22.3	16.2	0.06
WT	11.2	31.8	29.5	9.2	29.5	0.00
Com	14.7	48.7	9.6	20.8	20.8	0.06
TT	17.7	30.1	35.6	9.5	24.8	0.07
Saf	50.7	50.7	8.5	20.4	20.4	0.03
Goal: Transportation Choice, Unit % for Other						
		Car	Mot	BRT	LRT	CR
Overall EV		41.1	19.0	17.4	22.4	0.05
TC	6	9.4	48.3	17.6	24.7	0.08
WT	12.7	48.3	24.7	9.4	17.6	0.08
Com	12.7	38.4	9.6	22.3	28.7	0.06
TT	25.6	33.1	30.0	13.1	23.8	0.08
Saf	43.1	48.7	9.6	20.8	20.8	0.06

Note: TC = Travel Time; WT = Waiting Time; Com = Comfort;
TT = Trave Time; Saf = Safety; EV = Eigenvector; Mot = Motor Bike;
BRT = Bus Rapid Transit; LRT = Light Rail Transit

Source: Arranged by the authors

As shown in Table 5, Workers preferred LRT overall with a score of 33.9%, which was immediately followed by Car (27.8%), Motorbike (22.4%), and BRT (16.1%). The primary reason was that Workers considered Travel Cost to be of greater importance than Waiting Time. LRT and BRT shared 20.4% of Travel Cost, which was much higher than Car (8.5%). Moreover, for the other factors such as Comfort, Travel Time, and Safety, LRT had the highest share where Workers were concerned.

On the other hand, Students' preferred alternative travel mode was Car, with an overall

score of 42.5%, because of privacy and fashion reasons. In the Comfort factor, Student's preference for Car was 48.7%, while Workers' and Other/Exporter's preferences were 22.3% and 38.4%, respectively. In summary, Table 5 shows that Student and Other/Exporter occupations prefer Car Travel, followed by LRT, while the Worker occupation prefers LRT followed by Car Travel.

3.4 Gender scenario, factor prioritization

Table 6 below shows that between Male and Female categories, the rankings of mode choices were the same, but varied in scores as follows: (1) Car (Male-33.3%, Female-42.5%), (2) LRT (Male-23.2%, Female-22.0%), (3) Motorbike (Male-22.8%, Female-18.1%), and (4) BRT (Male-20.7%, Female-17.4%). However, in terms of factors, Females primarily preferred Safety, Comfort, and Travel time, with scores of 39.4%, 20.0%, and 18.7%, respectively. The two other factors Waiting Time and Travel Cost were least preferred by women, with corresponding scores of 12.5% and 9.4%, respectively. In contrast, Comfort factor by Males is preferred by only 12.2%. Travel Cost (11.0%) was the least important for males and females, and Safety came first with the high scores of 45.2% and 39.4% in both groups. The research indicates that females are more likely to think about comfort compared to males. However, females had about 6% lower rate of preference in terms of safety compared to males. In addition, females' preference for Cars is 9% higher than males'. Regarding the number of trips, females traveled less at 3.8 trips per week compared to males' 5.4 trips per week.

Table 6. Weight of Alternative with respect to gender

Goal: Transportation Choice, Unit % for Male						
		Car	Mot	BRT	LRT	CR
Overall EV		33.3	22.8	20.7	23.2	0.04
TC	11	12.8	41.9	29.5	14.8	0.03
WT	13.4	34.0	28.1	14.0	23.9	0.02
Com	12.2	28.8	16.9	20.5	33.8	0.02
TT	18.2	33.0	33.0	14.0	20.0	0.02
Saf	45.2	29.5	14.0	23.2	23.2	0.02
Goal: Transportation Choice, Unit % for Female						
		Car	Mot	BRT	LRT	CR
Overall EV		42.5	18.1	17.4	22.0	0.02
TC	9.4	16.3	29.5	27.8	16.3	0.02
WT	12.5	39.5	23.2	14.0	23.2	0.02
Com	20	29.9	25.3	20.9	23.9	0.07
TT	18.7	24.3	34.3	17.2	24.3	0.05
Saf	39.4	36.6	12.4	23.3	27.8	0.02

Note: TC = Travel Time; WT = Waiting Time; Com = Comfort;
TT = Trave Time; Saf = Safety; EV = Eigenvector; Mot = Motor Bike;
BRT = Bus Rapid Transit; LRT = Light Rail Transit

3.5 Vehicle ownership Scenario, Factor prioritization

Table 7 below shows that between Car ownership and Motorbike ownership, rankings of mode choices were slightly different in the Car ownership case, where LRT scored 25.4%

as the second choice, while BRT was chosen to be the third at 22.5%. They also differed in scores as follows: (1) Car (Car owner-33.5%, Motorbike owner-31.4%), (2) LRT (Car owner-25.4%, Motorbike owner-22.8%), (3) BRT (Car owner-22.5%, Motorbike owner-25.5%), and (4) Motor Bike (Car owner-18.6%, Motorbike owner-20.4%). In terms of factors, Motorbike owners primarily preferred Safety, Comfort, and Travel time, with scores of 47%, 16.7%, and 16.4%, respectively. The other two factors, Waiting time and Travel Cost, were least important to motorbike owners, with corresponding scores of 11.0% and 8.8%, respectively. The research indicates that motorbike users are more likely to think about comfort compared to car users.

Table 7. Weight of Alternative with respect to vehicle ownership

Goal: Transportation Choice, Unit % for Car Ownership						
		Car	Mot	BRT	LRT	CR
Overall EV		33.5	18.6	22.5	25.4	0.04
TC	8.7	19.8	39.5	16.8	23.9	0.02
WT	10.7	30.9	30.9	14.2	24.1	0.06
Com	12.6	27.8	12.4	23.3	36.6	0.02
TT	16	21.0	24.6	29.8	24.6	0.02
Saf	49	42.4	12.2	22.7	22.7	0.00
Goal: Transportation Choice, Unit % Motorbike Ownership						
		Car	Mot	BRT	LRT	CR
Overall EV		31.4	20.4	25.5	22.8	0.03
TC	8.8	12.0	41.8	27.1	19.1	0.03
WT	11	34.7	18.0	23.7	23.7	0.09
Com	16.7	39.5	16.3	27.8	16.3	0.02
TT	16.4	23.9	34.0	14.0	28.1	0.02
Saf	47	34.0	13.6	28.7	23.7	0.07

Note: TC = Travel Time; WT = Waiting Time; Com = Comfort;
TT = Trave Time; Saf = Safety; EV = Eigenvector; Mot = Motor Bike;
BRT = Bus Rapid Transit; LRT = Light Rail Transit

4. CONCLUSION

This paper discusses the importance of understanding users' attitudes related to factors or criteria that account for their preferences regarding private and public transportation modes. The findings indicate that there is no way to change people's preferences regarding use of private vehicles, particularly cars. With the exception of the Worker case, all permutations of the survey conducted indicated Car Travel as the preferred mode of private transportation and Light Rail Trasit as the preferred mode of public transportation. Motorbikes and buses were the least preferred modes, even among motorbike owners. Note that even with these preferences, motorbikes are the primary means of transportation in Phnom Penh because of their affordability.

Safety is the most significant criterion for people when they travel. However, this criterion has negative significance in choice of public transportation. Therefore, if safe public transport is secured in the city, people may reduce their reliance on motorbikes and cars to travel within the city. People will choose safe public transport to avoid accidents and be less

exposed to crimes. In contrast, if public transportation safety is low, people who cannot afford cars will choose motorbikes instead. Finally, Travel Cost has the lowest consideration in the AHP evaluation for survey participants, reflecting the unavoidable necessity to travel, regardless of cost.

Other overall results indicate that service level categories, Time and Comfort, are very important features for promoting a public transportation system. Hine and Scott (2000) found that if a fair level of service is provided, fare and safety factors become less important in a public transportation service.

In conclusion, the AHP evaluation indicates that level of service, which includes Safety, Travel Time, Waiting Time, and Comfort, is more important than Travel Cost. Therefore, it is important to provide travel safety, followed by acceptable travel time; comfort (air conditioning, good seat conditions, and low noise); and last but not least, tolerable and accurate waiting times (i.e., schedules must be maintained).

Regarding external factors, the study concludes that employment is more significant than other external factors in promoting public transportation, particularly in the case of LRT. In most urban areas, use of public transit is dropping because of decreases in employment in city centers (Gomez-Ibanez, 1996). However, Table 5 shows that LRT is the preferred travel means by Workers (33.9%) in Phnom Penh City. Furthermore, the AHP results indicate that LRT could become the preferred choice for Students and Exporters (Others) if consistent levels of service are provided.

For lower income and young age groups, Travel Cost is more important than Travel Time. In contrast, Travel Time seems to be more important than cost for upper income (students and businessmen) and older people. Elderly people do not travel frequently, and as a result, they demonstrate nearly equal preference for all alternatives. However, Car preference is still dominant for senior citizens, followed by LRT, BRT, and Motorbikes as the least preferred choice because of the physical difficulties of riding a motorbike.

The study concludes that gender difference is also significant in certain areas. Results indicate that there are no differences between mode choice rankings. However, the difference between genders is more pronounced when considering internal factors, as the Female category seems to care about convenience and comfort more than travel time and waiting time, while the Male category shows least priority for comfort. Moreover, research has found that Car owners are more likely to use LRT than Motorbike owners, as Motorbike owners preferred BRT to LRT. The Motorbike owners surveyed care about comfort more than Car owners by over 4%.

To summarize, the study revealed that employment in particular, along with age and distance, is more significant than other external factors considered in the survey. Furthermore, the study suggests that level of service is more important in influencing the decision to travel than changes in Travel Cost regarding public transportation. However, providing reasonable fares will attract a significant portion of survey participants, including young people, low-income people, and workers employed in the city. In addition, to attract more females or motorbike owners to public transit, it is necessary to provide as much comfort as possible.

This research was performed to focus on the implementation of a public transportation system in Phnom Penh City, Cambodia, in order to achieve sustainable and environmentally friendly transportation within the city. Clarifying the most important factors addressed above should define the priorities necessary to implement a sustainable system. Conducting this survey made people in some areas aware of the lack of an existing public transportation system and gave them an idea and opportunity to participate in future plans for the development of a transportation system in Phnom Penh City.

Implementing a public transportation system is an effective means to achieve the goal of developing better policies in the overall transportation sector by reducing private vehicle use. Benefits include reduction in air pollutants such as CO_2 and NOx and in traffic congestion. The overall credit weights (EV) represent the importance of the criteria based on transportation users' perspectives and ideals of the survey participants. The AHP evaluation presented in this paper provides a viable means to evaluate passenger preferences regarding a public transportation system, particularly in an urban area, considering implementation of a new system. Additional data refinement can be obtained by a larger survey and/or adding other preference factors where pertinent. The results of the AHP survey indicate that a Light Rail System with reasonable cost (fare price) and high service levels would attract the greatest number of passengers in Phnom Penh City. Challenges to consider will be narrowness of existing roadways and terminal locations.

REFERENCES

Best, H., & Lanzendorf, M., (2005). Division of labor and gender differences in metropolitan Car use: An empirical study in Cologne, Germany, *Journal of Transport Geography*, 13 (2), 109-121.

Boarnet, M. G., & Sarmiento, S., (1998). Can land-use policy really affect travel behaviour? A study of the link between non-work travel and land-use characteristics, *Urban Studies*, 35 (7), 1155-1169.

Choocharukul, K. and M. H. UNG, (2011). Propensity to Switch to a New Bus Service in Phnom Penh using Stated Preference Analysis: *Asian Transport Studies, Vol. 1, Issue 3*, pp. 277-287.

Embassy of France in Cambodia, (2002–2005). FSP Support for the project on the management of the urban management and development in Cambodia, Bureau of Urban Affairs, Municipality of Phnom Penh.

Expert Choice, (1983/8). Decision Support Software Inc., McLean VA.

G. Beirao, & J. Sarsfield Cabral, (2007). Understanding attitudes towards public transport and a private car: A qualitative study, *Transport Policy*, 14 (6), pp. 478-489.

Giuliano, G., & Dargay, J., (2006). Car ownership, travel and land use: A comparison of the US and Great Britain, *Transportation Research Part A: Policy and Practice*, 40(2), pp. 106-124.

Handy, S., Weston, L., & Mokhtarian, P. L., (2005). Driving by choice or necessity? *Transportation Research Part A: Policy and Practice Positive Utility of Travel*, 39(2-3), pp. 183-203.

Hine, J., & Scott, J., (2000). Seamless, accessible travel: users' views of the public transport journey and interchange, *Transport Policy*, 7 (3), pp. 217-226.

Guiver, J. W., (2007). Modal talk: Discourse analysis of how people talk about bus and car travel, *Transportation Research Part A: Policy and Practice*, 41 (3), pp. 233-248.

KATAHIRA & ENGINEERS INTERNATIONAL & JICA, (2001). Final report of the study on the transport master plan of the Phnom Penh metropolitan area in the Kingdom of Cambodia, The Municipality of Phnom Penh, The Kingdom of Cambodia.LIM, Iv

Moriarty, P., & Honnery, D., (2005). Determinants of urban travel in Australia, 28th Australasian Transport Research Forum (ATRF).

National Institute of Statistics (July, 2010). General Population Census of Cambodia 2008 "Village Indicators Part1," Ministry of Planning, Phnom Penh, Cambodia.

Newbold, K. B., Scott, D. M., Spinney, J. E. L., Kanaroglou, P., & P□ez, A., (2005). Travel behavior within Canada's older population: a cohort analysis, *Journal of Transport Geography*, 13(4), pp. 340-351.

Olaru, D., Smith, N., & Peachman, J., (2005). Whereabouts Monday to Sunday? 28th Australasian Transport Research Forum (ATRF).

Phnom Penh Capital Hall, (2009). Urban Master Plan Phnom Penh Capital City for 2020, Report of Urbanization office of the Phnom Penh City.

Polk, M., (2003). Are women potentially more accommodating than men to a sustainable transportation system in Sweden? Transportation Research Part D: Transport and Environment, 8(2), pp. 75-95.

Saaty, R.W., & Vargas, L.G. (Eds.), (1987). The analytic hierarchy process, *Mathematical Modelling*, 9, pp. 3-5.

Saaty, T.L., (1977). A scaling method for priorities in hierarchical structures, *Journal of Mathematical Psychology*, 15, pp. 234-281.

Saaty, T.L., (1980). The Analytic Hierarchy Process, NY, McGraw Hill

Rosenbloom, S., & Fielding, G. J., (1998). Transit markets of the future: The challenge of change, TCRP Report 28, TRB, National Research Council, Washington, D.C.

Saaty, T. L., (1994). How to make a decision: The analytic hierarchy process, *Interfaces*, 24 (6), pp. 19-43.